Stratospheric Ozone Variability at Table Mountain, California (34.4°N, 117.7°W)

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Abstract. A wide range of temporal variability in stratospheric ozone profiles is investigated using more than 10 years of DIAL-ozone lidar measurements at the Jet Propulsion Laboratory (JPL), Table Mountain Facility (TMF), California.

Dataset

As part of the Network for the Detection of Stratospheric Change (NDSC) the differential absorption lidar (DIAL) system at TMF has been providing high-resolution vertical profiles of ozone number density since 1988 between approximately 18 and 50 km, and 2 to 3 nights a week on average [e.g., *McDermid et al.*, 1990, 1993]. The dataset is summarized in figure 1.

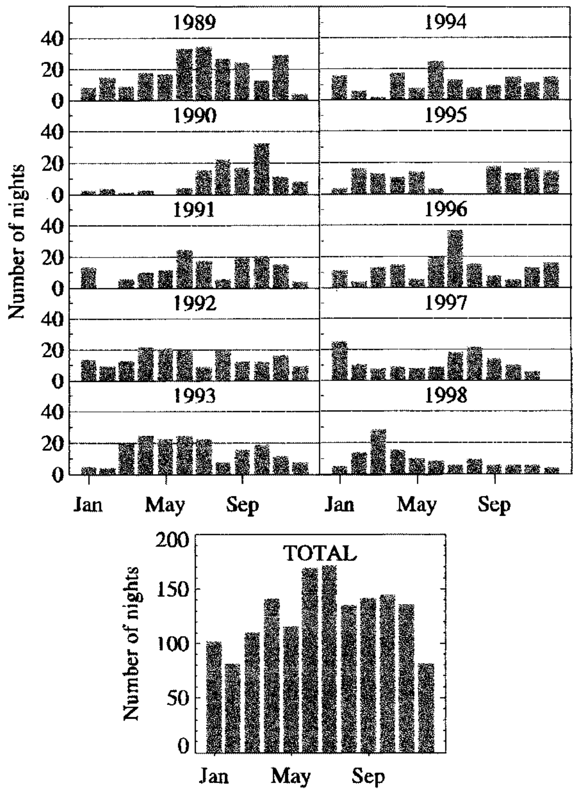

Figure 1. Summary and distribution of ozone lidar measurements at Table Mountain since 1988.

The current instrumental vertical resolution is 300 m but the system was operated with a 600 m resolution until September 1994. During analysis the raw data are vertically filtered to reduce the instrumental noise. The vertical resolution of the ozone profiles (defined as the minimum vertical wavelength of an oscillation whose magnitude is halved after filtering) is almost 1 km near the ozone peak. It decreases to ~ 3 km at the bottom of the profiles, and to 8-10 km at the top of the profiles. For a typical experiment the minimum instrumental error, which occurs at the ozone peak, is a few percent. This error increases to 10-15 % at the bottom of the profile (~15 km) and increases to more than 40% above 45 km due to the combined reduction in the returned signal and the lower ozone concentration at these altitudes. No results for altitudes above 45 km will be discussed in this paper.

In the present study the ozone concentration profiles have been interpolated to a 1-km vertical interval in order to homogenize the entire data set. This operation reduces the magnitude of smaller vertical scale fluctuations but the latter are not needed for a climatological study. Figure 2 shows two typical ozone profiles measured in late winter and mid-summer. As expected for midlatitudes the ozone concentration peak is stronger and located lower in winter (5.5×10^{12} cm^{-3} at 23 km) than in summer (4.5×10^{12} cm^{-3} at 25-26 km). The natural variability in the ozone concentration is also higher in winter and spring in the lower stratosphere where frequent thin strong peaks (laminae) of 6-6.5 x 10^{12} cm^{-3} have been observed in March around and below 20 km. Such a feature is weakly observable in figure 2 near 20 km.

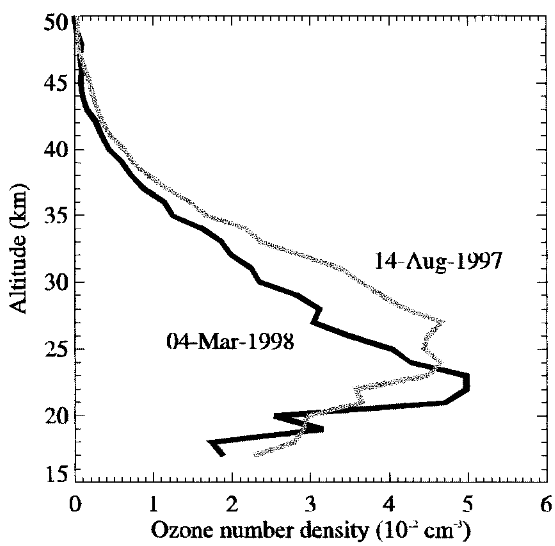

Figure 2. Typical wintertime and summertime ozone profiles.

Results

The overall mean ozone number density was calculated as a function of altitude. The mean profile obtained is representative of an annual mean since the data distribution for each month is similar (see Fig. 1). The deviations (%) from this quasi-annual mean have been plotted for each day of measurement in figure 3 for 4 characteristic altitudes. The results are displayed in the form of a single composite year. The vertical bars indicate the 1σ errors (%) associated with each data point. The thick solid line is the filtered data for each day of the composite year when at least one measurement has been performed that day-of-year. The filter scheme, a 2nd order polynomial fitted over a 65-day wide window, takes into account the quality of each measurement. This way less weight is given to shorter and/or noisier experiments with larger error bars.

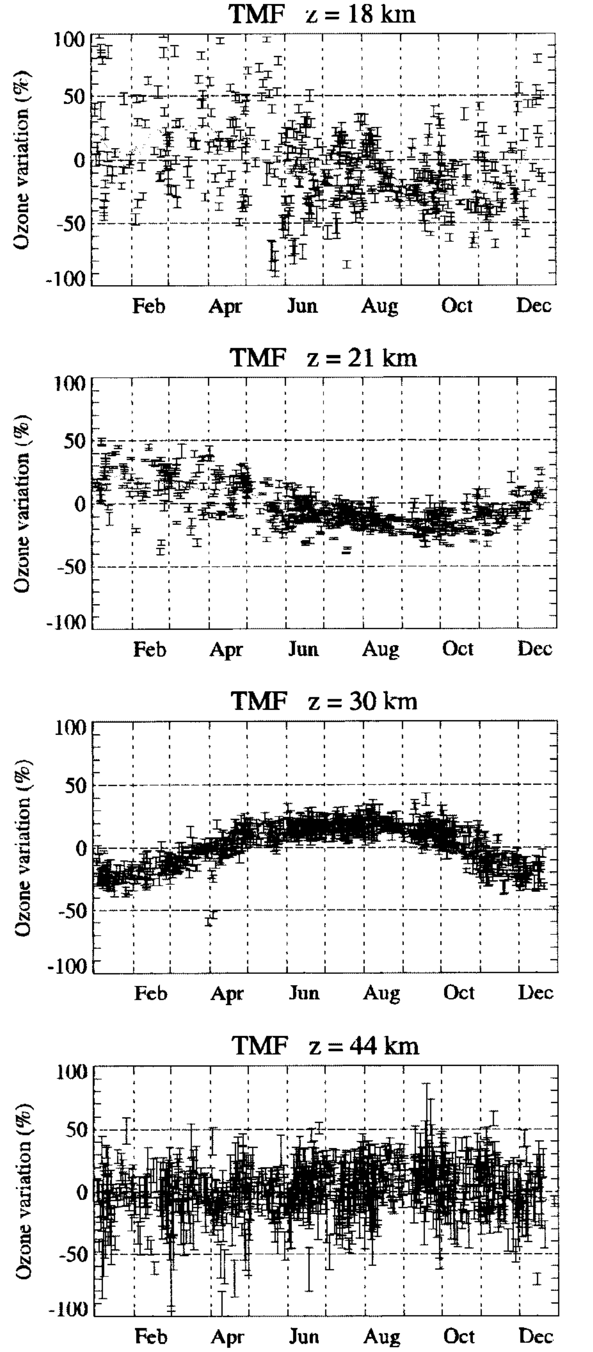

Figure 3. Seasonal variation (in percent) of stratospheric ozone number density at 4 characteristic altitudes: From top to bottom: 18 km, 21 km, 30 km, and 44 km. The vertical bars indicate the calculated total error at 1σ for each plotted measurement. The thick gray solid line shows the 65-day filtered data.

It can be seen in figure 4 that the seasonal variations below and above the ozone peak (~ 23 km) are inverted. At 30 and 44 km the maximum occurs in late summer and the minimum in winter, consistent with a radiatively driven ozone abundance. At 18 and 21 km, the maximum occurs in late winter early spring and the minimum in late summer, typical of a dynamically driven winter lower stratosphere, where polar and midlatitudes relatively rich ozone air masses frequently intrude into subtropical latitudes such as that of Table Mountain (34.4°N). The magnitude of the winter-peak to summer-peak variation is discussed later in this paper. The natural variability indicated by the magnitude of the deviations is much higher in the dynamically driven region (frequently as much as ±50% at 18 km), as a consequence of the midlatitudes planetary wave activity [*Perliski et al.*, 1989]. It is much weaker at 30 km, region where the radiative effects are dominant. At 44 km the large error bars do not allow unequivocal conclusions, but an apparent low variability seems consistent with the observed low variability at 30 km.

The ozone concentrations between the top of the profiles (50-55 km) and the altitude of 20 km are systematically integrated in the analysis process and converted to Dobson units. The seasonal variation of the stratospheric ozone column is shown in figure 4. A well-defined annual cycle is observed with a maximum of about 220 DU in summer and a minimum of 185 DU in winter. The annual cycle showing a maximum in summer is typical of the total ozone seasonal variations [*Bowman and Krueger*, 1985] suggesting that not too much information is lost by not including levels below 20 km.

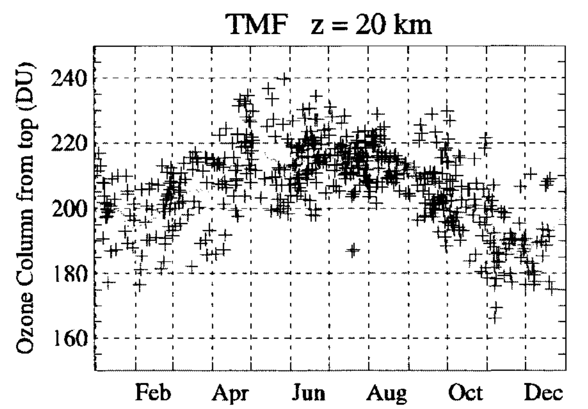

Figure 4. Seasonal variation of the stratospheric ozone column.

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References

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